United States Patent [19]

Piccirillo et al.

[54] **AIRPORT INTEGRATED HAZARD RESPONSE APPARATUS**

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[58] Field of Search 342/29, 30, 32, 342/36, 37

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,599,143	8/1971	Brown et al.	340/958
3,872,474	3/1975	Levine	342/36
3,971,025	7/1976	Levine	342/410
4,481,516	11/1984	Michelotti	340/933
4,516,125	5/1985	Schwab et al.	342/36
5,097,268	3/1992	Bauer, Jr. et al.	342/160
5,300,933	4/1994	Discenza et al.	342/36
5,334,982	8/1994	Owen	342/36
5,374,932	12/1994	Wyschogrod et al.	342/36
5,400,031	3/1995	Fitts	342/36

OTHER PUBLICATIONS

"Airport Movement Area Safety System", by M. Watnick and J. Ianniello, United Technologies Norden Systems, Inc., prepared for IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA Oct. 5–8, 1992.
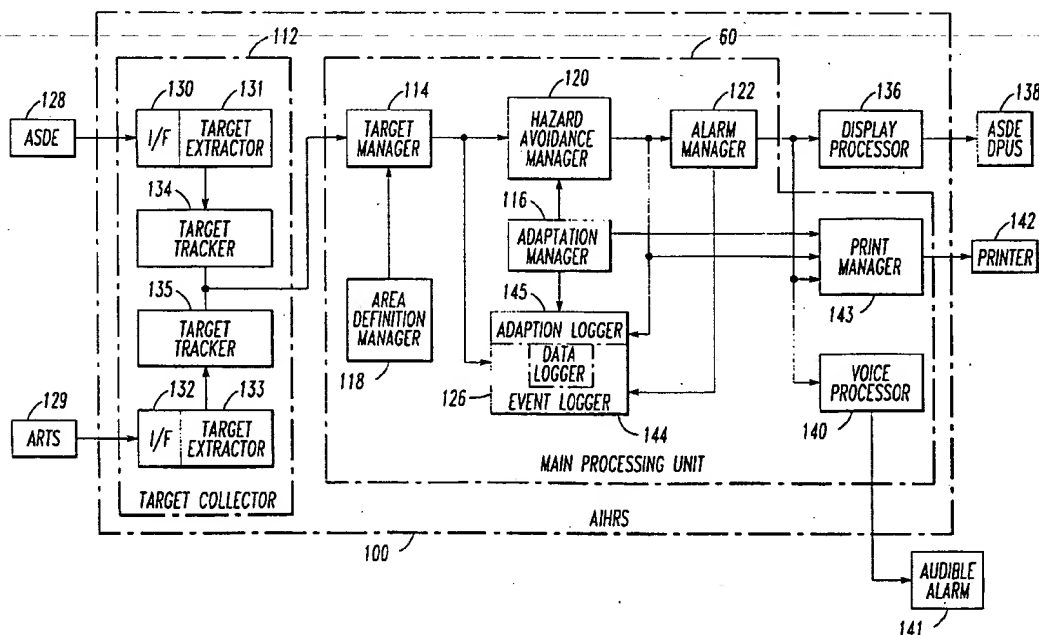
"Airport Surface Collision Warning System Implementation", by J. Ianniello, R. Kruczek, United Technologies Norden Systems, Inc. presented at IEEE/AIAA Digital Avionics Systems Conference and Technical Display, Fort Worth, TX, Oct. 25–28, 1993.
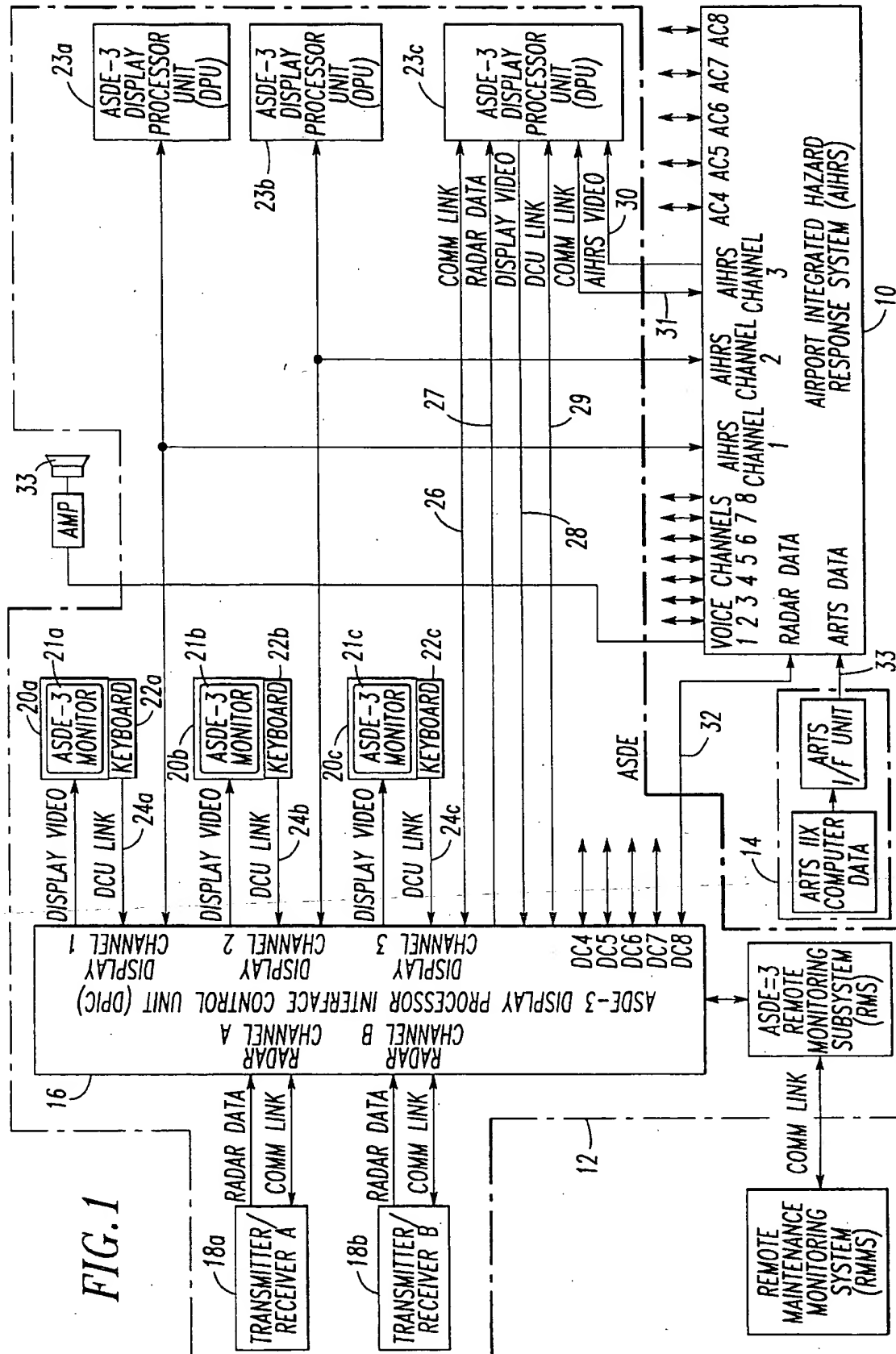
Primary Examiner—John B. Sotomayor
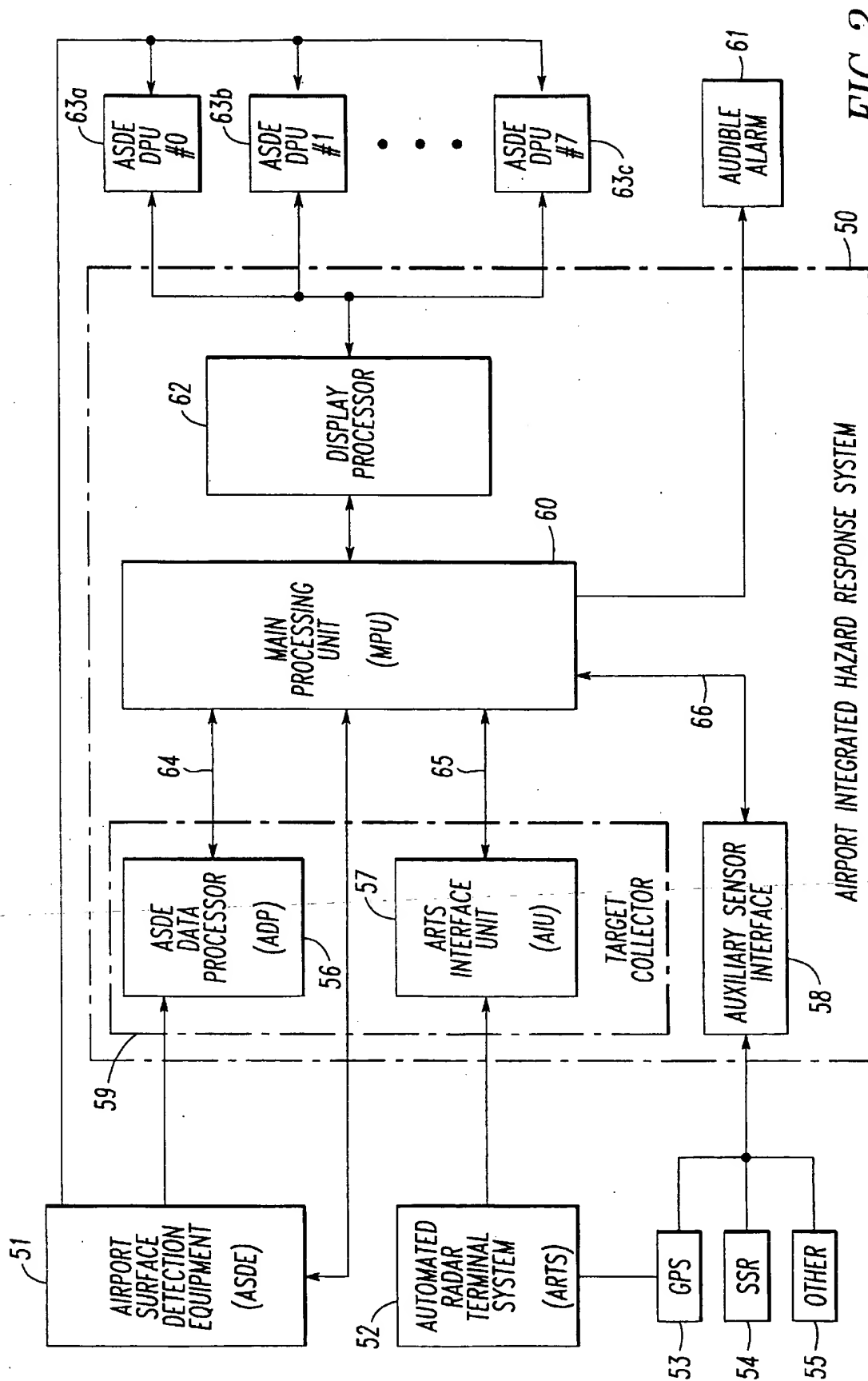*Attorney, Agent, or Firm*—Christopher O. Edwards

[57] **ABSTRACT**

An apparatus for monitoring the position of multiple objects in a space including a target supervisor, a location supervisor, and a hazard monitoring supervisor. The tracking supervisor receives target data from a sensor, characterizes and tracks selected objects, and provides a target output having multiple features respective of the selected objects. The location supervisor characterizes and displays multiple features in the space, and provides a location output having the aforementioned features therein. The hazard monitoring supervisor detects and responds to a predetermined hazard condition, and provides a detectable notice of such hazard condition, responsive to the target output and the location output. A data logger for selectively retains the target output, the location output, or both. The position monitoring apparatus has six modes: full operation, non-airport-surveillance-radar, isolation, set-up, adaptation, and simulation. An integrator mode is included wherein the target supervisor receives data from a surface detection radar, an airborne surveillance radar, a secondary surveillance radar, a global positioning-system based sensor, a ground-based sensor, or an auxiliary sensor.
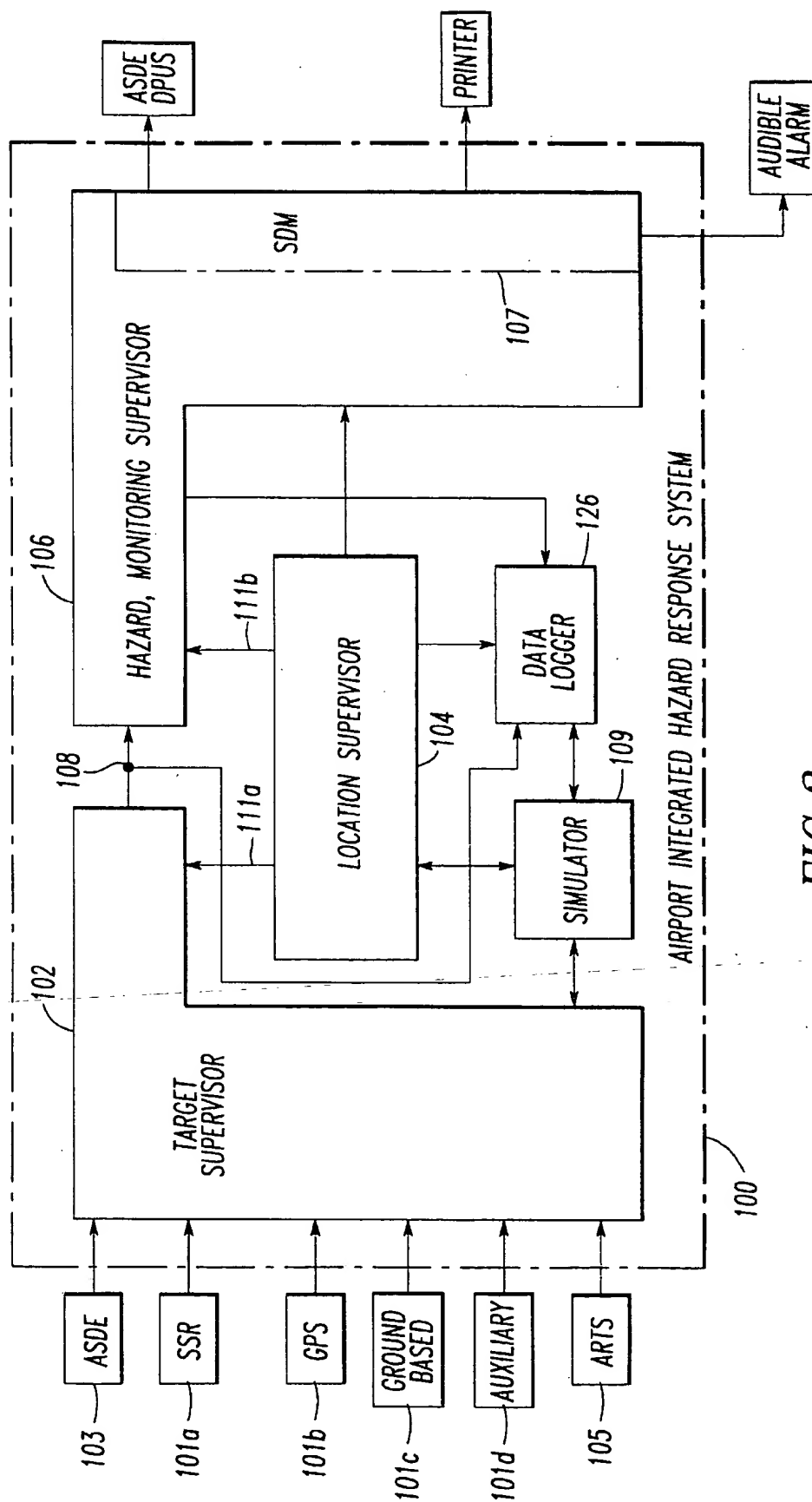
33 Claims, 4 Drawing Sheets

FIG.1

FIG.2

ASDE DPUS

PRINTER

AUDIBLE ALARM

SDM

107

HAZARD, MONITORING SUPERVISOR

106

LOCATION SUPERVISOR

111b

111a

104

108

DATA LOGGER

126

SIMULATOR

109

TARGET SUPERVISOR

102

100

AIRPORT INTEGRATED HAZARD RESPONSE SYSTEM

ASDE   103

SSR   101a

GPS   101b

GROUND BASED   101c
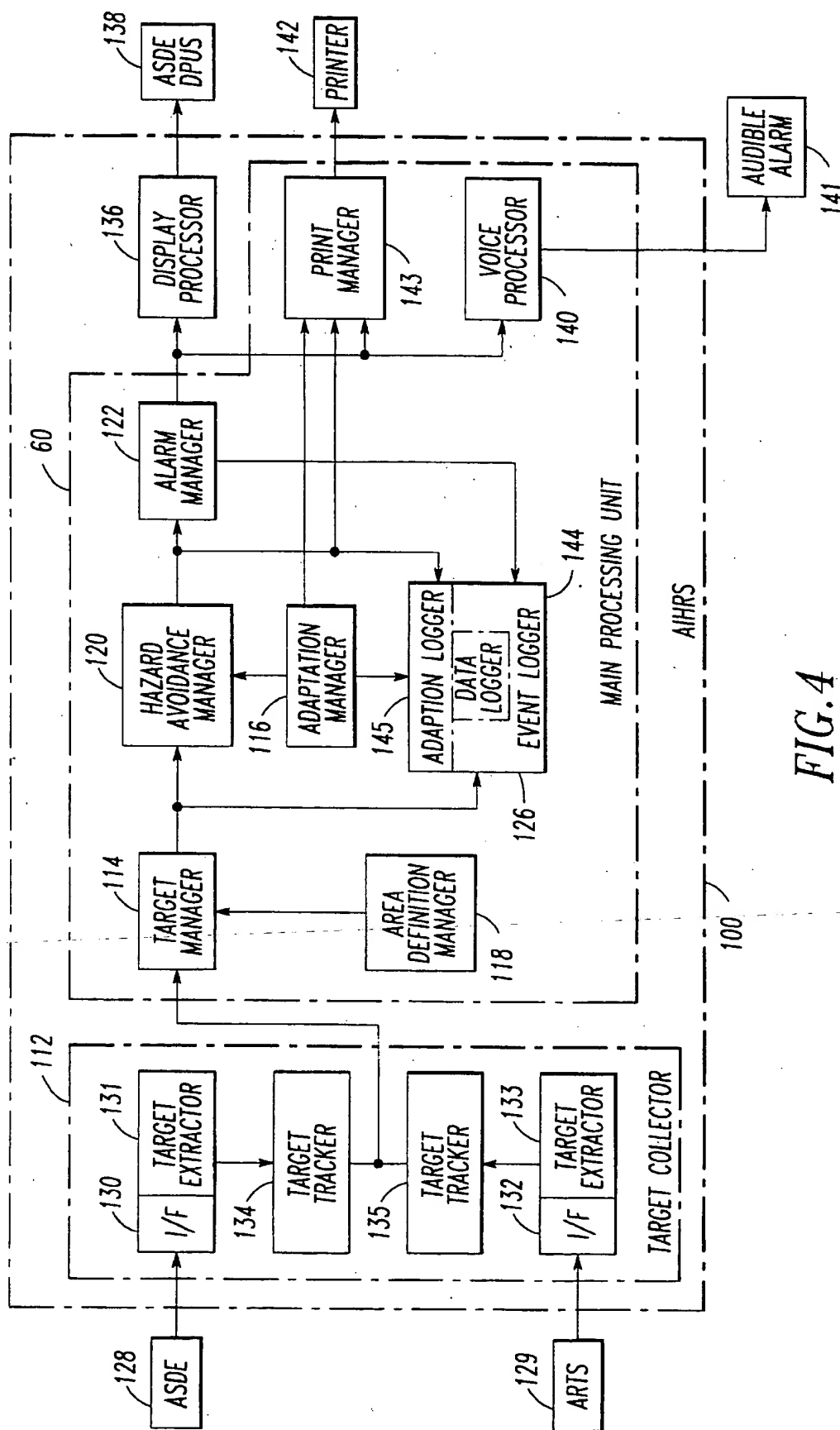
AUXILIARY   101d

ARTS   105

FIG.3

FIG. 4

AIRPORT INTEGRATED HAZARD RESPONSE APPARATUS

BACKGROUND OF THE INVENTION

This application is related to co-pending patent application Ser. No. 08/494,118, filed Jun. 23, 1995, entitled "Aircraft Landing Determination Apparatus and Method," which is incorporated herein by reference and which is assigned to the same assignee hereof.

1. Field of the Invention

The invention herein regards air traffic control systems, and particularly to air traffic control systems integrating airborne and ground-based target tracking and providing an integrated hazard response.

2. Description of the Prior Art

Accidents involving aircraft and ground vehicles and aircraft ground collisions can occur at busy airports. More than three times as many near-accidents occur on the ground as in the air. In one such accident, an aircraft strayed onto the wrong runway and was struck by a second aircraft, resulting in a loss of life. In another accident, two aircraft collided when one aircraft was cleared to land on an occupied runway. Continuous situation monitoring in fog, snow, at night, and under other adverse conditions, can cause fatigue in human controllers which may lead to a collision between objects on airport surfaces.

Medium-range airport surveillance radar, such as the Automated Radar Terminal System (ARTS) is good for detecting and tracking many aircraft within a large volume of airspace. However, such systems do not provide adequate surveillance coverage for ground-resident objects, including aircraft that are in the taxiing, holding (stopped), takeoff or landing phases of their flight profiles.

Airport surface detection equipment (ASDE) systems can provide high-resolution, short-range, clutter-free, surveillance information on aircraft and ground vehicles, both moving and fixed, located on or near the surface of airport movement and holding areas under all weather and visibility conditions. An ASDE system formats incoming surface detection radar information for a desired coverage area, and presents it to local and ground controllers on high-resolution, bright displays in the airport control tower cab.

However, an ASDE system will be effective only if the controllers are observing the radar display, which may be unlikely during good visibility conditions. The increasing sophistication of electronic equipment in air traffic control towers can result in an increasing number of computer displays and alarms. The large number of displays and keyboards in the tower cab can result in a cramped and cluttered environment which may be relieved by an integrated display apparatus. In addition to ASDE and ARTS systems, other sensor systems such as, for example, secondary surveillance radar (SSR), and global positioning system (GPS) can provide logically disparate parameters in physically disparate locations within the tower cab, further adding to the controllers' burden. The lack of integration between sensor systems in the tower cab, including ARTS, ASDE, SSR, GPS, and the like, can yield gaps in controller awareness of the unfolding situation.

\In addition, a large, busy airport is an environment having a vast number of possible conflict situations. In such a dynamic environment, the potential for collision between any given aircraft and any one of possibly many ground-resident, and nearby airborne, objects may not be recognized

until it is too late to avoid the collision. Also, the occurrence of a conflict in one area of the airport may draw controllers' attention away from evolving conflict situations.

What is needed is apparatus which can integrate inputs from disparate sensor systems to aid controllers in adverse conditions, such as poor visibility conditions or peak traffic periods, and provide an improved means of detecting and alerting the controller to pending surface conflict.

SUMMARY OF THE INVENTION

The invention herein provides an apparatus for monitoring the position of multiple objects in a predefined space including a target supervisor, a location supervisor, and a hazard monitoring supervisor. The tracking supervisor characterizes and tracks selected objects, receiving target data from at least one sensor. The target supervisor provides a target output having multiple predetermined features respective of the selected objects. The location supervisor characterizes and displays multiple, predetermined features respective of the predefined space, and provides a location output having the aforementioned predetermined features therein. The hazard monitoring supervisor detects and responds to at least one predetermined hazard condition. It provides a detectable notice of such hazard condition, responsive to the target output and the location output. The apparatus can also include a data logger for selectively retaining the target output, the location output, or both.

The target supervisor can include a target collector for extracting at least one target track from the target data, and tracking it over a predetermined period of time. The target supervisor further can include a target manager for determining the predetermined features respective of the selected objects responsive to the target data. The location supervisor can include an adaptation manager for providing selected portions of the predetermined features respective of the predefined space. The hazard monitoring supervisor can include a hazard avoidance manager which can respond to the predetermined hazard condition according to a predetermined selectable set of hazard avoidance logic rules. The hazard monitoring supervisor can also include an alarm manager for determining a manner of presentation of the detectable notice. In addition, the hazard monitoring supervisor can include a situation display manager for providing a visual display, an aural display, or a printed display, responsive to the predetermined hazard condition. The data logger can include an event logger as well as an adaptation logger. The target collector can include a first interface unit between a surface detection radar and the position monitor, and a second interface unit for connection between an airport surveillance radar and the position monitor.

The position monitoring apparatus can have six modes: a full operation mode, a non-airport-surveillance-radar mode, an isolation mode, a set-up mode, an adaptation mode, and a simulation mode. It also can have an integrator mode wherein the target supervisor receives the target data from multiple sensors, at least one sensors being of a type different from a respective other. In this mode, the target supervisor can integrate the disparate target data to provide the target output thereby. Each of the sensors from which the target supervisor can receive data is from the group consisting of a surface detection radar, an airborne surveillance radar, a secondary surveillance radar, a global positioning-system based sensor, a ground-based sensor, and an auxiliary sensor.

Other details, objects, and advantages of the invention will become apparent as the following description of certain

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present preferred embodiments thereof proceeds. The accompanying drawings show presently preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of the functional relationship between an ASDE system, an ARTS system, and the AIHR according to the invention herein.

FIG. 2 is a block diagram of one embodiment of the AIHR.

FIG. 3 is a illustration of one embodiment of the functional components of the AIHR.

FIG. 4 is a detailed block diagram of the AIHR shown in FIG. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention herein can provide an airport integrated hazard response apparatus (AIHR) and supply controllers with automatic conflict warnings and alerts, enabling them to act swiftly to reduce the incidence of collisions and other runway and taxiway accidents. The AIHR can analyze surface object movements for indications of possible threats, and can automatically alert controllers to inadequate vehicle spacing, inappropriate or unauthorized movements or positioning within the airport area and its associated airspace, and even runway debris. Such objects can include aircraft, trucks, people, animals, and the like. The AIHR can track a preselected number of targets including aircraft on final approach, as well as those that are departing or landing, and objects, including aircraft, that are taxiing or stopped. Targets may be represented as computer-generated symbols, improving display readability.

The AIHR can provide the ASDE-3 or other surveillance display with an overlay of symbology on the display map coordinates covering the entire airport which may be zoomed, windowed, offset, and rotated. This information may also be remotely linked to displays at other locations including in aircraft or vehicles. By zooming in on a particular area of interest, controllers in the tower cab or other observers can see images of planes, ground vehicles, and people on the ground on the radar display consoles. The AIHR can provide position monitoring of a predefined space which can include airport surfaces at the ground and a preselected range of air space thereabove, for example, 200 feet in altitude or 10 miles in range.

The AIHR can utilize information from a number of sources to develop current and projected locations of moving objects compared to defined data surfaces. In addition to surface-based data from an ASDE system, such other sources may include, for example, nearby-airborne-target data from ARTS, tracking data from SSR, absolute spatial location data from GPS devices, and vectored location information from squittering systems. The AIHR provides fusion of disparate sensor data so that controllers can comprehend and respond appropriately to the nature and priority of a plurality of possible hazard situations.

Predicted and actual trajectories of each object are computed and compared with the predicted and actual trajectories of all other objects in a predefined space, which space may include a ground surface and a preselected portion of air space thereabove. Based on information such as the movement state, previous locations, vehicle type and size, surface type, surface status, airport geometry, and the like, AIHR can

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determine if each moving object exceeds allowable preset limits for each surface, movement state, and surface type and status with respect to other objects. It can also determine if objects remain stationary on surfaces beyond allowed preset limits.

The surface of interest can be divided into predetermined segments so that object locations may be determined relative to those segments. Each segment may, in turn, be divided into a plurality of hazard logic cells, each of which may be analyzed for the existence of a potential conflict. A hazard avoidance manager can analyze the plurality of data inputs to classify an existing situation. The existence of the alert condition can be raised by a comparison of the actual situation with graphical data tables which may contain predefined rules such as, for example, spacing rules based on factors such as surface configuration and the object movement state. These alerts may be used to create voice and display messages or audio/visual alarms, and can control traffic lights, data link messages to operators, and send information to remote master controllers or vehicle operators.

The AIHR can provide visual and aural alarms for runway incursions. Advisories for cautions and warnings involving aircraft, vehicles and obstacles on active runways, approach paths to runways, and intersecting taxiways can be provided. Visual alarms may be provided at each controller position with an ASDE-3 display. A common tower cab aural alarm can be provided via loud speaker in the tower cab. Map editors may be provided in the adaptation manager to define areas of interest, such as runways and intersecting taxiways for which valid sensor data is available. This information can be provided to the hazard monitoring supervisor to detect potentially hazardous situations.

The AIHR can have a display processor which generates display information mixed with information provided to ASDE operational display units (ODU) to provide overlaid video images. In addition, the entry device for AIHR can be the ASDE-3 display control unit (DCU), or a local personal computer or computer workstation platform (collectively, PC platform). AIHR equipment may be kept in the tower equipment room except for a loud speaker and amplifier in the tower cab therefore reducing the amount of equipment required in the tower cab. AIHR can communicate with a plurality of ASDE display channels, for example, eight ASDE display channels.

FIG. 1 illustrates the operation of AIHR 10 in conjunction with ASDE system 12 and ARTS system 14. ASDE system 12 can be of the ASDE-3 type, or system 12 can be another surveillance system, or display system, or both. In general, the ASDE display processor interface control (DPIC) unit 16 can receive data from radar transceivers 18a, 18b. Each of ASDE controller work stations 20a–c can include monitor 21a–c for data display and input devices 22a–c for data entry by controllers. Each of work stations 20a–c can be associated with ASDE display processor unit 23a–c, respectively. DPIC 16 routes display video signals 24a–c to monitors 21a–c from the respective DPU 23a–c. Similarly, DPIC 16 routes controller input receive through DCU link 25a–c to respective DPU 23a–c. Although not shown specifically in conjunction with DPU 23a and 23b, the various signals communicated by DPIC 16 and a DPU are shown with regard to DPU 23c. For example, DPIC 16 and DPU 23c can share communication data along bidirectional communication link 26. Radar data 27 are received by DPU 23c and processed to provide display video 28, which in turn, is routed to ASDE monitor 21c. Controller information input and display control signals are transmitted along DCU link

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29 between DPIC **16** and DPU **23c**. It is possible for AIHR **10** to provide additional display information to the controllers by providing an additional video signal **30** for processing by DPU **23c** which signal **30** is mixed with other data within DPU **23c** to form a composite video signal which is transmitted by display video signal **28** to ASDE monitor **21c** or other display as commanded to the DPIC. Communication between AIHR **10** and DPU **23c** may be facilitated by bidirectional communication link **31**. To provide the radar data necessary for hazard analysis and response, and video input to DPU **23a–c**, radar signal **32** can be provided to AIHR **10** from DPIC **16**. AIHR **10** can also accept data signal **33** from ARTS unit **14** so that radar returns from airborne aircraft can be fused in AIHR **10**, processed for safety checks, transmitted to DPU **23c** via video signal **30** or both, and be routed to DPIC **16** over display video signal **28** for display on monitor **21c** on workstation **20c**. AIHR **10** can provide audible signals through audible alarm **33**, which signals may include synthesized voice and tone signals. AIHR **10** can work with either ASDE system **12** or ARTS system **14**, or both, and with other auxiliary sensor systems.

FIG. 2 illustrates one embodiment of an airport integrated response apparatus according to the invention herein. AIHR **50** can collect and fuse data from disparate sensors such as, for example, ASDE system **51**, ARTS system **52**, GPS sensor **53**, SSR sensor **54**, and other sensor **55**, sensors **53**, **54**, and **55** being auxiliary sensors. As used herein, the term sensor is inclusive of a particular detector, such as a radar transceiver, and its associated processing equipment; one such sensor being ASDE system **51**. Because the data output by the aforementioned sensors may be presented to AIHR **50** at different data rates and in different physical and logical formats, interface units such as ASDE data processor (ADP) **56**, ARTS interface unit (AIU) **57**, and auxiliary sensor interface **58** can be used to present data to main processing unit (MPU) **60** in a suitable format. Collectively, ADP **56** and AIU **57** can be used, in part, to serve as target collector **59**. In addition to acting as an interface to ASDE system **51**, ADP **56** can provide additional signal processing for target extraction. ADP **56** may also perform target centroiding and target tracking. Similarly, AIU **57** can filter target data from the airport surveillance radar (ASR), track ASR targets, and provide a bidirectional data link between ASDE system **51** and ARTS system **52**. MPU **60** can collect sensor inputs from and provide control and responsive outputs to ADP **56**, AIU **57**, and interface **58** by way of bidirectional data links **64**, **65**, and **66**, respectively. In addition to sensor fusion, MPU **60** can correlate ASR and ASDE track files, manage target tracking and provide audible alert generation including synthetic voice and audible tone messages using audible alarm **61**. MPU **60** can also provide surface monitoring and situation analysis, employing a hazard monitoring supervisor. This supervisor can use selectable, predetermined hazard avoidance rules to determine the nature, probability, and priority of a plurality of possible hazard situations. A built-in self-test may also be incorporated into MPU **60**.

Display processor **62** can effect warning symbol generation including hold bars, icons, symbol blinking, and the like. Display processor **62** also acts as the display interface between AIHR **50** and ASDE system **51**. Processor **62** formats input for display on ASDE DPU **63a–c**. MPU **60** can include a PC platform such as a 80486-based personal computer or workstation system, with ADP **56**, AIU **57**, and interface **58** being connected to the PC platform by way of a MICROBUS channel.

The AIHR **50** can have six modes of operation. First, the full operating mode permits AIHR **50** to operate in conjunction with both the ASDE system **51** and ARTS system **52**. This is because separate ASDE and ARTS data extractors **56**, **57**, respectively, provide data to AIHR **50** for coordination of target data processing.

Second, in the "non-ARTS" mode, the AIHR **50** can be capable of operation without ARTS system **52**. In the event that there are no approaching aircraft, or ARTS unit **52** is not operational, the AIHR **50** can continue to process other input information, including ASDE returns, to monitor the position and movement of ground targets.

Third, in the isolation mode, AIHR **50** may be operated separately from ASDE system **51** without affecting the operation of ASDE system **51**. In this mode of operation, ASDE system **51** does not rely on AIHR **50** for inputs in data processing or display.

Fourth, the adaptation mode provides a unique setup for each runway traffic flow and each access to each runway, where feasible. Menus can be provided for each runway to specify both configuration and status.

Fifth, the setup mode specifies runway incursion logic parameters and system parameters. These parameters may be entered using the AIHR PC platform. In this mode, the tower staff can select a combination of runways and applicable traffic flows and parameters. The groupings of predefined runway configurations and associated definitions are buildable and selectable via keyboard to facilitate airport reconfiguration.

Sixth, a simulation mode can be provided to perform engineering development and training off line using recorded or scenario data and injected targets via PC platform input devices.

An integrator mode can also be implemented. In this mode, the target supervisor can integrate data from two or more disparate sensors such as, for example, surface detection radar, airborne surveillance radar, secondary surveillance radar, and global positioning system-based sensors, ground-based sensors, and other auxiliary sensors to produce the target output for the target tracker.

The AIHR apparatus can accept and retain both physical and operational runway and taxiway definitions, data separation rules, system parameters, and display alert priority conditions. The runway/taxiway physical data may be set-up upon installation of the apparatus. Separation parameters may be derived for each airport during apparatus testing and validation. Operational configurations and system parameters can be selectable. Alert priorities also can be selectable and may be programmed in software. Furthermore, adaptation runway data may be grouped into user selectable entities.

FIG. 3 present a functional illustration of an AIHR according to one embodiment of the invention herein. AIHR **100** provides an apparatus for monitoring the position of a plurality of objects in a predefined space having target supervisor **102** for characterizing and tracking a selected number of the objects, location supervisor **104** for characterizing and displaying predetermined features respective of the predefined space, and hazard monitoring supervisor **106** for detecting at least one predetermined hazard condition responsive to target supervisor output **108** and location supervisor output **110**, and for providing a detectable notice thereof. Hazard monitoring supervisor **106** can include situation display manager **107** for producing and managing the detectable notice which may include visual, aural, and printed notice.

FIG. 4 provides an illustration of AIHR **100** in FIG. 3 respective of a physical layout. Managers **114**, **116**, **118**, **120**,

122, and 143, logger 126, and processor 140 may be contained within MPU 60. Target supervisor 102 in FIG. 3 can include target collector 112 and target manager 114, seen in FIG. 4. Location supervisor 104 in FIG. 3 can include adaptation manager 116 and area definition manager 118, seen in FIG. 4. Hazard monitoring supervisor 106 in FIG. 3 can include hazard avoidance manager 120 and alarm manager 122, seen in FIG. 4. AIHR 100 can also include data logger 126 which may include an event logger and an adaptation logger.

Continuing in FIG. 4, target collector 112 can extract and track target information received from at least one of a surface detection object detector 128, which can be for example, an ASDE-3 radar system, and an airborne surveillance detector 129 which can be, for example, an ARTS radar system. Target collector 112 may also provide for synthetic target generation, injection, and playback, accepting target data from simulator 109.

Target collector 112 can extract targets of interest from input sensor data using target extractors 131, 133. Target extractor 131 can include first data interface 130 for extracting information from surface detection sensor 128, and target extractor 133 can have second interface 132 for receiving information from surveillance radar sensor 129. Together with the graphical areas defined by adaptation manager 116, AIHR 100 can acquire and track targets from surface detection and surveillance radar sensors 128, 129, respectively, on runways, taxiways, within intersections, and on approach paths. Extractors 131, 133 can use information such as airport geometry, target geometry, clutter map, and primary and secondary acquisition areas to isolate the targets of interest.

Target trackers 134 can provide a peak amplitude smear from the ASDE radar data to target manager 114. Target manager 114 can have a clutter filter, centroider, and an alpha/beta tracker. The clutter filter provides raw extracted target data to the centroider. The centroider locates the centroid of the extracted image received from the clutter filter. The resultant image centroid can then be provided to the alpha/beta tracker which can be sensitive to both straight-line movement and target maneuvering, and which can provide a next-position estimate and velocity for the target thereby.

Location supervisor 104 may also include an area definition manager 118 to provide selected milieu information therein to target supervisor 102. Included in the milieu information can be the aforementioned clutter map, as well as selected system parameters, predefined constant tables, defined area parameters, and target tracking information. Such system parameters can include Pulse Repetition Frequency (PRF) data from radar, tower height, mode of operation, clutter update frequency, and scale factors. Tabular information can include trigonometric coefficient tables, target ID table, and alpha/beta filter coefficient table. System definitions can include primary and secondary information acquisition areas, and clutter areas. Tracking information can include target status, position, and velocity, as well as selected other tracking parameters.

Area definition manager 118 can also include airport configuration data, and movement/direction parameters in the milieu information. Airport configuration data can include "normal" surface directions, and airport surface types. Movement/direction parameter inputs can include velocity threshold ranges, and travel direction windows. Furthermore, area definition manager 118 can include information such as, for example, surface directions, surface

direction codes, surface boundary coordinates, surface intersection coordinates, runway threshold coordinates, and segment data.

Target manager 114 can perform at least seven functions. First, it can maintain target reports from ASDE 128, the playback system, and a synthetic target injection device in target collector 112. Second, target manager 114 can generate target states for use by other components of the system. Third, target manager 114 can compute spatio-temporal parameters such as target velocities and accelerations. Fourth, target manager 114 can determine the current location of targets on airport surfaces. Fifth, target manager 114 can predict the future location of targets on airport surfaces based on information including prior target reports, computed spatio-temporal parameters, and current target locations. Sixth, target manager 114 can provide to display processor 136 target information, such as, for example, target identification, target type, and target position. Seventh, target manager 114 can detect target report anomalies.

Target manager 114, when provided surveillance and surface detection radar information from the first and second interface units, determines directions of movement with respect to movement areas, and classifies targets as either stopped or in one of a predetermined number of movement states. In addition, target manager 114 can predict future target locations based on derivation of velocity and acceleration information from previous position reports. In one embodiment, a second order fit of the previous five position reports can be used.

Target manager 114 can maintain target reports and compute target-related parameters such as, for example, velocities and accelerations. Target manager 114 can also generate target states which may be provided to hazard avoidance manager 120 for analysis. Also, target manager 114 can determine whether targets are on active runways and moving at speeds greater than or less than a selected speed parameter. Movement states may be based in part on detected vehicle speeds.

In general, target manager 114 analyzes and processes information regarding target location, direction, and movement. Target location can be with respect to a predefined position within the selected space, which can include a particular surface in the airport configuration. Target direction can be determined with respect to a particular surface direction.

Target manager 114 can determine target movement by comparing the target's current state with its previous state relative to a movement parameter database to provide the target movement data of interest. Target data can include information from at least one sensor, target identification data, position coordinates, velocity vectors, acceleration, and target state.

Target manager 114 can provide current and predicted target location information which includes the surface(s) on which each target is located as well as the surface type, which is based on the airport configuration. The current and predicted locations of each target can be provided by a particular spatial segment within the airport. In general, target direction can be used to determine whether the target is approaching an intersection, or other targets or objects.

Outputs from the target manager can include target location, target direction, and target movement state. Target location can include the particular surface number upon which the target is located. Target direction can be the states which include a normal direction, an opposite direction, a "in the direction of", a "not in the direction of", and general

direction, such as north, east, south, or west. Target movement states can include arrival, landing, departure, departure abort, taxi, and stop.

Simulator 109 can provide synthetic physical objects and tracks, and operational situations including simulated hazard conditions to target supervisor 102, location supervisor 104, and hazard avoidance supervisor 106. Simulator 109 can be used, for example, to inject a selected number of objects, including debris, ground vehicles, aircraft, and the like, into the desired predefined space in the vicinity of the airport, for purposes such as routine and hazard-response training.

Adaptation manager 116 can maintain the plurality of predetermined physical and operational features respective of a predefined space including, for example, spatial configurations of an airport at which the apparatus may be installed. The predetermined features can be maintained as graphical entities which, when used in conjunction with the target manager, can permit AIHR 100 to monitor targets on runways, taxiways, within intersections, on approach paths, and in the nearby airspace. Adaptation manager 116 can also maintain system parameters and support installation and operator data.

Hazard monitoring supervisor 106 can detect at least one predetermined hazard condition responsive to target supervisor 102 and location supervisor 104, as seen in FIG. 3. Hazard monitoring supervisor 103 in FIG. 3 can include hazard avoidance manager 120 which analyzes information received from target manager 114 and from adaptation manager 116. Hazard avoidance manager 120 detects undesirable conditions, or hazards, such as, the incursion of an object into a selected portion of the predefined space which is allocated to another object, such as, for example, an aircraft. In addition, hazard avoidance manager 120 identifies and assigns a priority to an alert condition as provided by a preselected hazard rule set.

Hazard avoidance manager 120 can use preselected parameters for analysis and detection of alert situations. Such parameters can include predetermined target separation parameters, airport configuration, and airborne and ground traffic situations. Separation parameters can include time separations, distance separations, times to intersections, and stop times on surfaces. The airport configuration can be with regard to runway/taxiway geometry, runway usage such as open/close, direction of movement, taxiway, and the like, and segment state such as, segment under repair, snow plowing, maintenance, and the like.

Airborne traffic situation information can include information regarding approaching traffic such as an object's location and an aircraft's landing runway assignment. On the other hand, ground traffic situation can include information regarding moving and stopped traffic or obstructions on surfaces. This can include locating movement, providing movement direction, velocity, and acceleration, and the vehicle state. The spatio-temporal relationship between the two targets, respective of the targets' position in the monitored space can be maintained in a set of hazard avoidance logic tables.

Hazard avoidance manager 120 can also provide target pair analysis by determining the relative positions of the target pair, and performing projection computations using the spatio-temporal parameters of the target pair to predictively select particular, predetermined projection situations which may be indicative of a hazard or alert situation. Such projection situations can include a "chase" situation, where two targets on a single surface are moving in the same direction, a "head-on" situation, where two targets on a

single surface are moving towards each other, and a "crossing" situation, where two targets are converging upon each other at an intersection. A no-problem situation can exist when either none of the aforementioned situations exits, or if, after target pair analysis, the target movements are projected to avoid a hazard or alert situation.

Using rules for intersections as delineated in the hazard avoidance logic tables in hazard avoidance manager 120, target manager 114 can determine whether a target is on a taxiway or runway which is intersecting with an active runway and is predicted to enter the taxiway or runway within a preselected number of seconds, determining if an alert is required. Hazard avoidance manager 114 can also assess the situation for landing an approaching aircraft to an active or inactive runway.

Hazard monitoring supervisor in FIG. 3 can include alarm manager 122, seen in FIG. 4, which can maintain the aforementioned alert priorities, can generate video and aural commands, and control the utilization of the alerts. Alert notification can include the use of graphic indicators such as icons around "caution" targets, a flashing icon around "warning" targets, fixed hold bars, moving hold bars, and arts indicator lines. Alert notification may also include the provision of an alert message window required by hazard avoidance manager 120. Audio alerts can also include voice alerts.

Alarm manager 122 can control the alert indications received from hazard avoidance manager 120 through prioritization, message scrolling, video display coordination, and repetitive alert suppression. With alert prioritization, messages may be displayed in priority order based on the alert type, the movement state and the direction of target movement in an alert message window. With selective message scrolling, the five highest priority messages will remain on the display in the alert message window. Messages can remain on queue while the voice alarm alert is active. Those active messages which may have scrolled off of the message window can be redisplayed when the space is available.

Under video display coordination, voice messages may not be interrupted and the display can contain the message. In addition, text messages can remain active on the display while an incursion persists, and for at least as long as the spoken voice alert is provided. Repetitive alerts can be suppressed where subsequent alerts for the same targets and same conditions may not be reissued.

Alarm manager 122 can prioritize multiple alerts. For example, a warning has a higher priority than a caution. A situation involving two targets has a higher priority than one involving one target, for a single target conditions on the runway take priority over conditions on a taxiway. Vehicles moving in a direction opposite to what is considered "normal" for the surface have a higher priority than vehicles moving in the normal direction. Departures, arrivals, and landings have higher priority than taxied or stopped vehicles. Also, new conditions have a higher priority than sequential alerts for the same target. Every message can be assigned an individual priority.

In general, a message processor in alarm manager 122 retrieves alert data from an alert queue, determines the classification and relative priority of the alert, and updates the display target status. Problem targets may be sent to display processor 136. Voice message and alert display messages may be generated with the message content based on alert condition and the associated surface areas involved. Text messages may also be sent to display processor 136. In

addition, if there are multiple messages, the message processor processes the next alert in the queue. Also, the message processor handles fresh alerts by cleaning up obsolete alerts.

Situation display manager 107 in FIG. 3 can provide video and aural alert information to the air traffic controllers via ASDE DPUs 138. The visual and aural situation indicia can include, for example, icons, alarm messages, menus, ARTS indicator lines, and fixed and moving hold bars, and are provided to DPUs 138 as video signals which can be transmitted to the ASDE display unit and overlaid upon the ASDE video display.

If an alert condition exists from an approaching aircraft, the alert condition is displayed on the approach to the active runway using an ARTS indicator line. The ARTS indicator line is displayed next to the runway image to indicate the distance from the runway threshold, for example, three miles. Alarm manager 122 can display live target symbols, alert messages, and airport configurations for both live and simulated situations on both the AIHR PC platform and the ASDE-3 displays by way of display processor 136. Alert message positioning on the display can be controlled by the operator.

Hold bars and alerts may be used to indicate the advisability of entering an active runway. Each surface segment may be divided into the preselected number of hazard logic cells for which alerts may be generated or suppressed. A moving hold bar may be placed in front of any targets involved in situations for which such is specified in the hazard logic tables. Fixed hold bars may be displayed at intersections and removed from intersections when the target passes them. Fixed hold bars can be activated along all intersections in front of landing, departing, departure abort aircraft, and approaching aircraft within a selectable distance of the runway threshold.

Situation display manager 107 in FIG. 3 may also contain print manager 143 and voice processor 140, seen in FIG. 4. Print manager 143 can print current adaptation parameters or alternate sets of airport configuration adaptation parameters which are available for selection. Voice processor 140 can generate synthetic voice aural alerts which may be provided in the tower cab separately from the ASDE operational display units. Furthermore, print manager 143 manager can provide a hard copy of a particular situation by generating a printed report.

AIHR 100 can also include data logger 126 which may retain situational information such as, the data pertinent to a particular event, and the data associated with a particular set of features respective of the monitored space, for example, adaptation data. Data logger 126 can have the capability to record all setup data including safety and system parameters, maps, configurations, and clutter maps. It can also record cautions, warnings, controller queues, and target data. This information can be time-tagged whenever an update in an item occurs. Other information such as adaptation conditions, events, and selective area filtering data can be recalled from storage by the operator for future use.

While specific embodiments of practicing the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting to the scope of the invention which is to be given the full breadth of the following claims, and any and all embodiments thereof.

We claim:

1. An apparatus for monitoring the position of a plurality of objects in a predefined space comprising:

(a) a target supervisor for characterizing and tracking selected ones of said plurality of objects, said target supervisor receiving target data from at least one sensor, said target supervisor providing a target output having a first plurality of predetermined features respective of said selected ones;

(b) a location supervisor for characterizing and displaying a second plurality of predetermined features respective of said predefined space, said location supervisor providing a location output having said second plurality of predetermined features therein; and

(c) a hazard monitoring supervisor for detecting and responding to at least one predetermined hazard condition and providing a detectable notice thereof, said hazard monitoring supervisor being responsive to said target output and said location output.

2. The apparatus of claim 1 further comprising a data logger for selectively retaining at least one of said target output and said location output.

3. The apparatus of claim 1 wherein said target supervisor further comprises a target collector for extracting at least one target track from said target data, said target collector tracking said at least one target track over a predetermined period of time.

4. The apparatus of claim 1 wherein said target supervisor further comprises a target manager for determining said first plurality of predetermined features respective of said selected ones responsive to said target data.

5. The apparatus of claim 1 wherein said characterizing and tracking selected ones by said target supervisor includes predicting at least one of said first plurality of predetermined features in said target output.

6. The apparatus of claim 4 wherein said determining by said target manager includes predicting at least one of said first plurality of predetermined features respective of said selected ones responsive to said target data.

7. The apparatus of claim 1 wherein said location supervisor includes an adaptation manager for providing selected portions of said second plurality of predetermined features respective of said predefined space.

8. The apparatus of claim 1 wherein said location supervisor includes an area definition manager for providing selected milieu information.

9. The apparatus of claim 1 wherein said detecting and responding by hazard monitoring supervisor includes projecting a first position of a first target, projecting a second position of a second target, comparing said first position with said second position, and determining a preselected projection situation from said comparing.

10. The apparatus of claim 9 wherein said preselected projection situation includes one of a chase situation and a head-on situation and a crossing situation and a no-problem situation.

11. The apparatus of claim 1 wherein said hazard monitoring supervisor further comprises a hazard avoidance manager, said hazard avoidance manager responding to said at least one predetermined hazard condition according to a predetermined selectable set of hazard avoidance logic rules.

12. The apparatus of claim 10 wherein said hazard monitoring supervisor further comprises a hazard avoidance manager, said at least one predetermined hazard condition including said preselected projection situation, said hazard avoidance manager responding to said at least one predetermined hazard condition according to a predetermined selectable set of hazard avoidance logic rules.

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13. The apparatus of claim 1 wherein said hazard monitoring supervisor further comprises an alarm manager for determining a manner of presentation of said detectable notice.

14. The apparatus of claim 1 wherein said hazard monitoring supervisor further comprises a situation display manager for providing at least one of a visual display and an aural display and a printed display, said providing being responsive to said at least one predetermined hazard condition.

15. The apparatus of claim 2 wherein said data logger includes an event logger.

16. The apparatus of claim 2 wherein said data logger includes an adaptation logger.

17. The apparatus of claim 3 wherein said target collector further comprises a first interface unit between a surface detection radar and said target extractor and an second interface unit for connection between an airport surveillance radar and said target extractor.

18. The apparatus of claim 1 having at least one of a full operation mode and a non-airport-surveillance-radar mode and an isolation mode and a set-up mode and an adaptation mode and a simulation mode.

19. The apparatus of claim 1 having an integrator mode wherein said target supervisor receives said target data from a plurality of sensors, at least one sensor of said plurality of sensors being of a type different from a respective other of said plurality of sensors, said target supervisor integrating said target data to provide said target output thereby.

20. The apparatus of claim 19 wherein said at least one sensor is from the group consisting of a surface detection radar and an airborne surveillance radar and a secondary surveillance radar and a global positioning-system based sensor and a ground-based sensor and an auxiliary sensor.

21. The apparatus of claim 19 wherein said respective other is from the group consisting of a surface detection radar and an airborne surveillance radar and a secondary surveillance radar and a global positioning-system based sensor and a ground-based sensor and an auxiliary sensor.

22. The apparatus of claim 1 further comprising a simulator for simulating the presence of a selected number of said plurality of objects in said predefined space, said simulator being connected to said target supervisor, said location supervisor, and said hazard monitoring supervisor.

23. An apparatus for monitoring the position of a plurality of objects in a predefined space comprising:

(a) a target supervisor for characterizing and tracking a selected number of said plurality of objects, said target supervisor receiving target data from at least one sensor, said target supervisor providing a target output having a first plurality of predetermined features respective of said selected ones, said target supervisor having a target collector and a target manager, said target collector for extracting at least one target track from said target data, said target collector tracking said at least one target track over a predetermined period of time, and said target manager for determining said first plurality of predetermined features respective of said selected ones responsive to said target data;

(b) a location supervisor for characterizing and displaying a second plurality of predetermined features respective of said predefined space, said location supervisor providing a location output, said location supervisor having an adaptation manager for providing selected portions of said second plurality to said location output, said location supervisor having an area definition manager for providing selected milieu information, said location supervisor being operably connected to said target supervisor; and

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(c) a hazard monitoring supervisor for detecting and responding to at least one predetermined hazard condition and providing a detectable notice thereof, said hazard monitoring supervisor being operably connected to said target supervisor and said location supervisor, said hazard monitoring supervisor being responsive to said target output and said location output, said hazard monitoring supervisor having a hazard avoidance manager and an alarm manager and a situation display manager, said hazard avoidance manager responding to said at least one predetermined hazard condition according to a predetermined selectable set of hazard avoidance logic rules, said alarm manager for determining a manner of presentation of said detectable notice, said situation display manager for providing at least one of a visual display and an aural display and a printed display, said providing being responsive to said at least one predetermined hazard condition.

24. The apparatus of claim 23 wherein said characterizing and tracking selected ones by said target supervisor includes predicting at least one of said first plurality of predetermined features in said target output.

25. The apparatus of claim 23 further comprising a data logger for selectively retaining at least one of said first plurality of said target output and said second plurality of said location output, said data logger having an event logger and an adaptation logger.

26. The apparatus of claim 23 having at least one of a full operation mode and a non-airport-surveillance-radar mode and an isolation mode and a set-up mode and an adaptation mode and a simulation mode.

27. The apparatus of claim 23 further comprising a simulator for simulating the presence of a selected number of said plurality of objects in said predefined space, said simulator being connected to said target supervisor, said location supervisor, and said hazard monitoring supervisor.

28. The apparatus of claim 23 having an integrator mode wherein said target supervisor receives said target data from a plurality of sensors, at least one sensor of said plurality of sensors being of a type different from a respective other of said plurality of sensors, said target supervisor integrating said target data to provide said target output thereby.

29. The apparatus of claim 28 wherein said at least one sensor is from the group consisting of a surface detection radar and an airborne surveillance radar and a secondary surveillance radar and a global positioning-system based sensor and a ground-based sensor and an auxiliary sensor.

30. The apparatus of claim 29 wherein said respective other is from the group consisting of a surface detection radar and an airborne surveillance radar and a secondary surveillance radar and a global positioning-system based sensor and a ground-based sensor and an auxiliary sensor.

31. The apparatus of claim 23 wherein said detecting and responding by hazard monitoring supervisor includes projecting a first position of a first target, projecting a second position of a second target, comparing said first position with said second position, and determining a preselected projection situation from said comparing.

32. The apparatus of claim 31 wherein said preselected projection situation includes one of a chase situation and a head-on situation and a crossing situation and a no-problem situation.

33. The apparatus of claim 31 wherein said at least one predetermined hazard condition including said preselected projection situation.

* * * * *

claims 52 + 56
57 + 60 Col. 6 + Col 8
Col. 3

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Crinon (45) **Date of Patent: Oct. 5, 2004**

(54) **AUDIO/VIDEO SYSTEM WITH AUXILIARY DATA**

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(51) Int. Cl.^{7} **H04N 7/12; H04N 7/18; G06K 9/46**

(52) U.S. Cl. **375/240.26; 375/240.08; 382/243; 725/74**

(58) Field of Search 375/240.26, 240.24, 375/240.09, 240.01, 240; 348/414.1, 420.1, 429.1, 423.1, 554; 382/242, 243; 343/397.1; 345/302, 157, 719; 707/526, 101; 709/217; 725/105, 142, 131

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,065,345 A	11/1991	Knowles et al.	
5,109,482 A	4/1992	Bohrman	
5,276,805 A	1/1994	Hamaguchi	395/164
5,367,621 A	11/1994	Cohen et al.	395/154
5,448,726 A	9/1995	Cramsie et al.	395/600
5,453,779 A	9/1995	Dan et al.	
5,528,513 A	6/1996	Vaitzblit et al.	
5,539,871 A	7/1996	Gibson	
5,563,648 A *	10/1996	Menand et al.	725/105
5,572,643 A	11/1996	Judson	395/793
5,596,705 A	1/1997	Reimer et al.	
5,708,845 A	1/1998	Wistendahl et al.	

6,079,566 A *	6/2000	Eleftheriadis et al.	707/101
6,092,107 A *	7/2000	Eleftheriadis et al.	725/74
6,151,017 A *	11/2000	Suzuoka et al.	345/302
6,377,309 B1 *	4/2002	Ito et al.	345/554

FOREIGN PATENT DOCUMENTS

EP	0 596 823 A3	5/1994
EP	0 596 823 A2	5/1994

OTHER PUBLICATIONS

Koenen, Bob, "MPEG–4: Context and Objectives," Signal Processing: Image Communication, 1997, vol. 9, pp. 295–304.

Ebrahimi, Touradj, MPEG–4 Video Verification Model: A Video Encoding/Decoding Algorithm Based on Content Representation, Signal Processing: Image Communication, 1997, vol. 9, pp. 367–384.

Burrill, Victoria, "Time–varying Sensitive Regions in Dynamic Multimedia Objects: A Prgamatic Approach to Content–Based Retrieval From Video," Information and Software Technology, 1994, vol. 36, pp. 213–223.

"Multimedia Hypervideo Links for Full Motion Videos," IBM Technical Disclosure Bulletin, vol. 37, No. 4A, Apr. 1, 1994, p. 95.
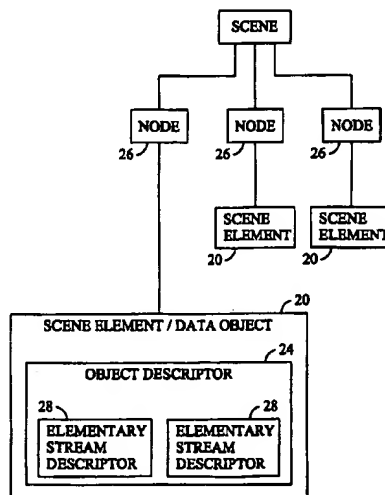
* cited by examiner

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(57) **ABSTRACT**

A video system includes a plurality of frames of video each of which is defined by a plurality of scene elements. The scene elements for a respective frame together define an image of the frame. First auxiliary data is descriptive of a first scene element of the frame and second auxiliary data is descriptive of a second scene element of the frame. A sending device sends the frame of video, including its scene elements, the first auxiliary data, and the second auxiliary data, from the sending device to a receiving device.
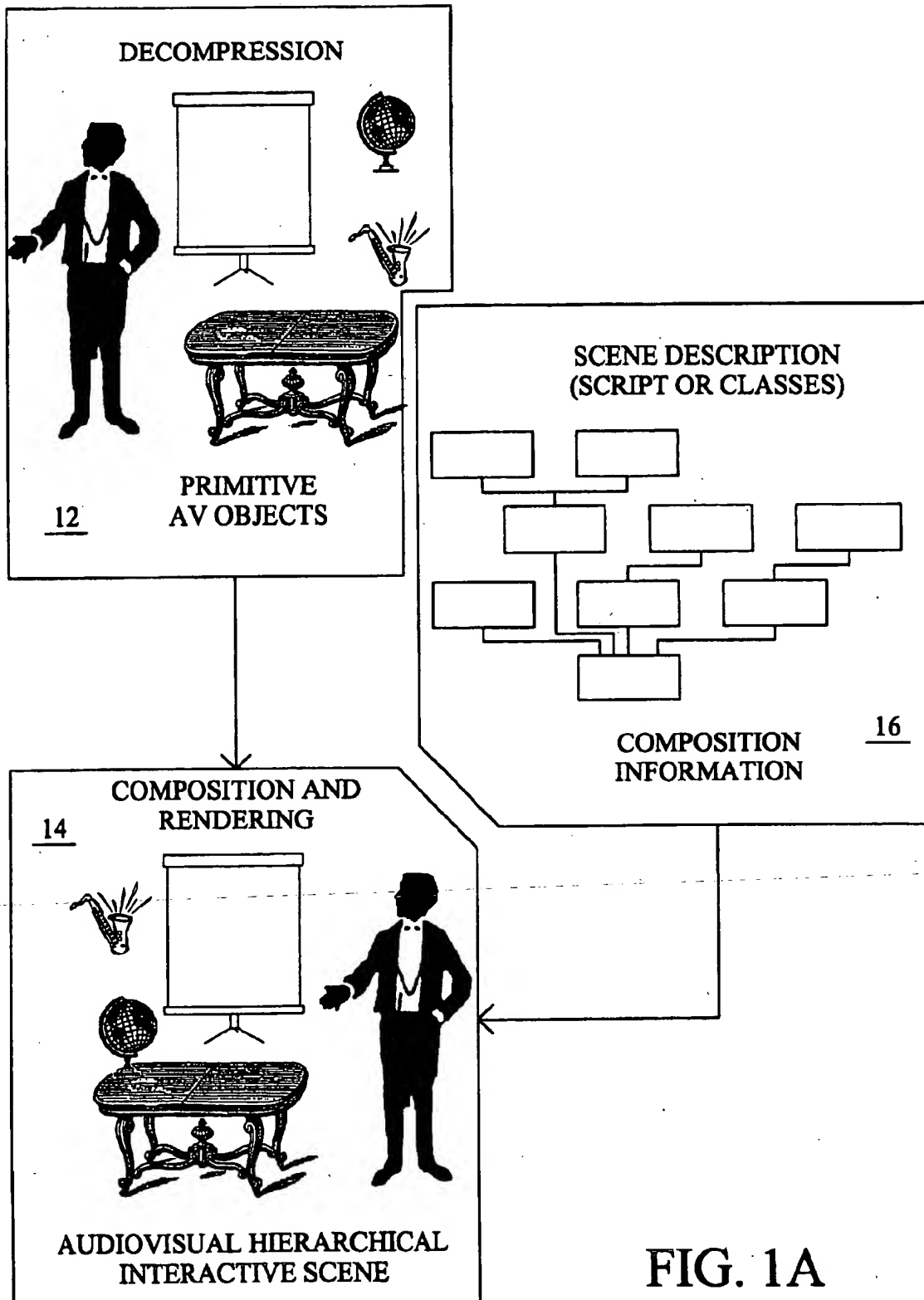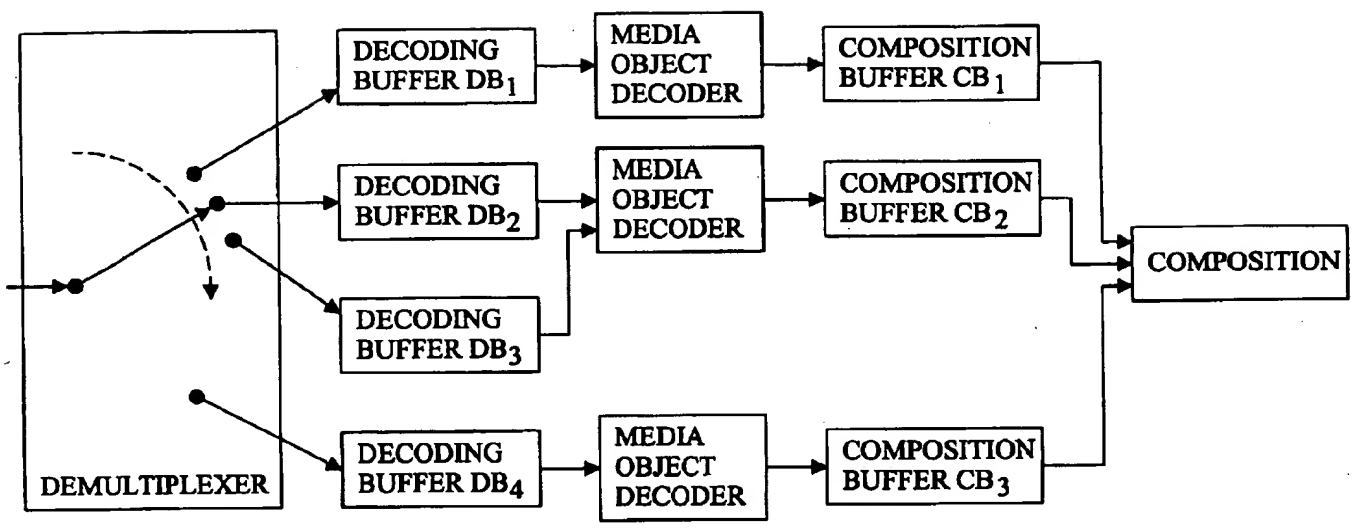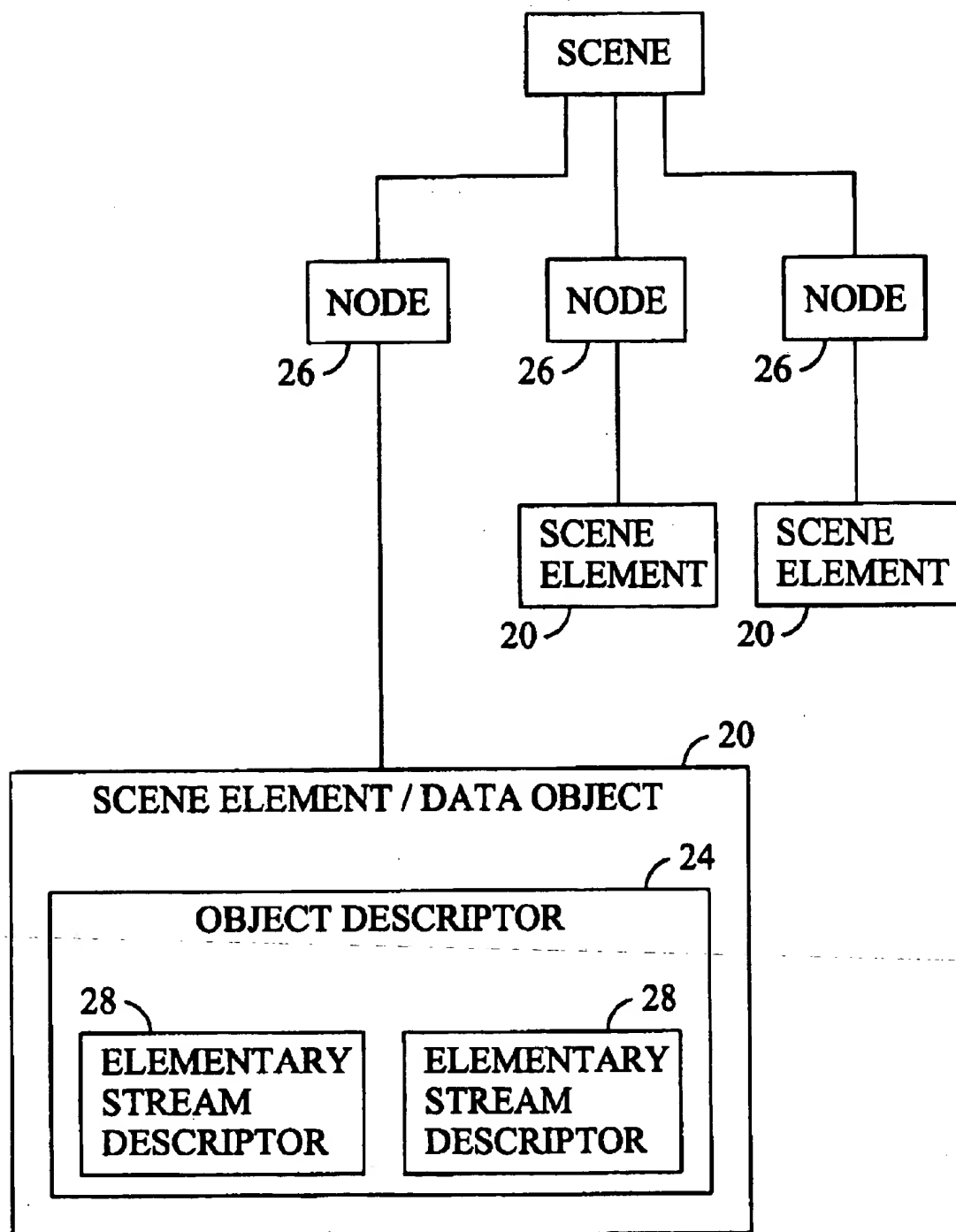
18 Claims, 5 Drawing Sheets

DECOMPRESSION

PRIMITIVE
AV OBJECTS

12

SCENE DESCRIPTION
(SCRIPT OR CLASSES)

COMPOSITION
INFORMATION

16

COMPOSITION AND
RENDERING

14

AUDIOVISUAL HIERARCHICAL
INTERACTIVE SCENE

FIG. 1A

FIG. 1B

FIG. 2

OBJECT DESCRIPTOR

OBJECT DESCRIPTOR ID

NUMBER OF ELEMENTARY STREAMS

28 — ELEMENTARY STREAM DESCRIPTORS

FIG. 3

ELEMENTARY STREAM DESCRIPTOR   28

ELEMENTARY STREAM ID NUMBER

30 — MULTIPLEXER CONFIGURATION

32 — DECODER TYPE (SCENE DESCRIPTON, OBJECT DESCRIPTOR, VISUAL STREAM, AUDIO STREAM, OR MPEG-7 STREAM)

34 — QUALITY OF STREAM REQUIREMENTS

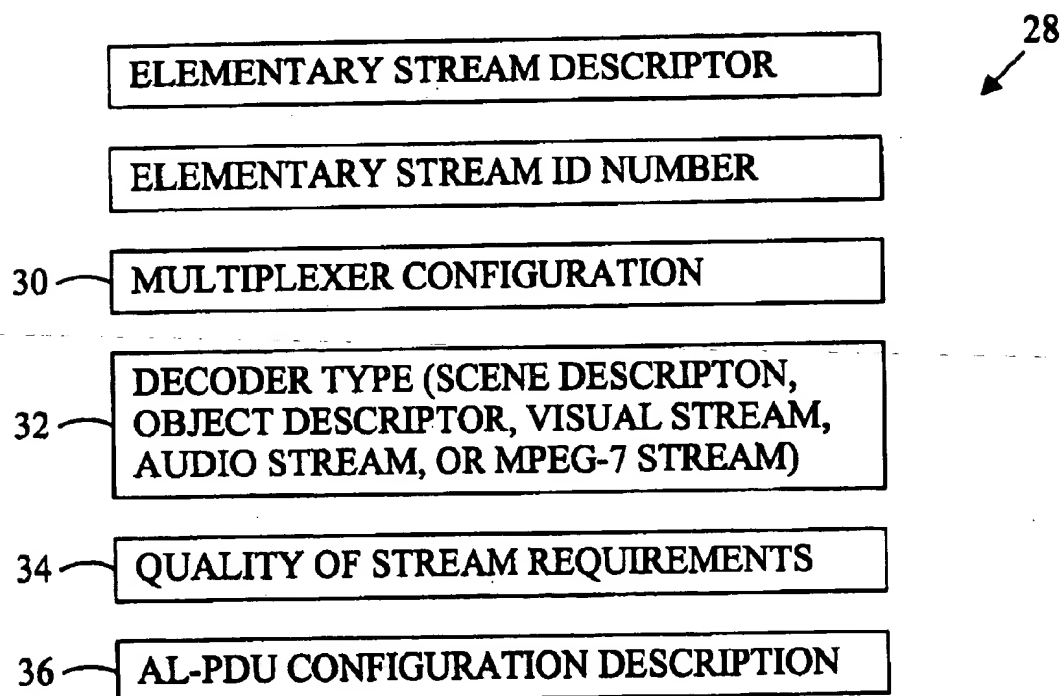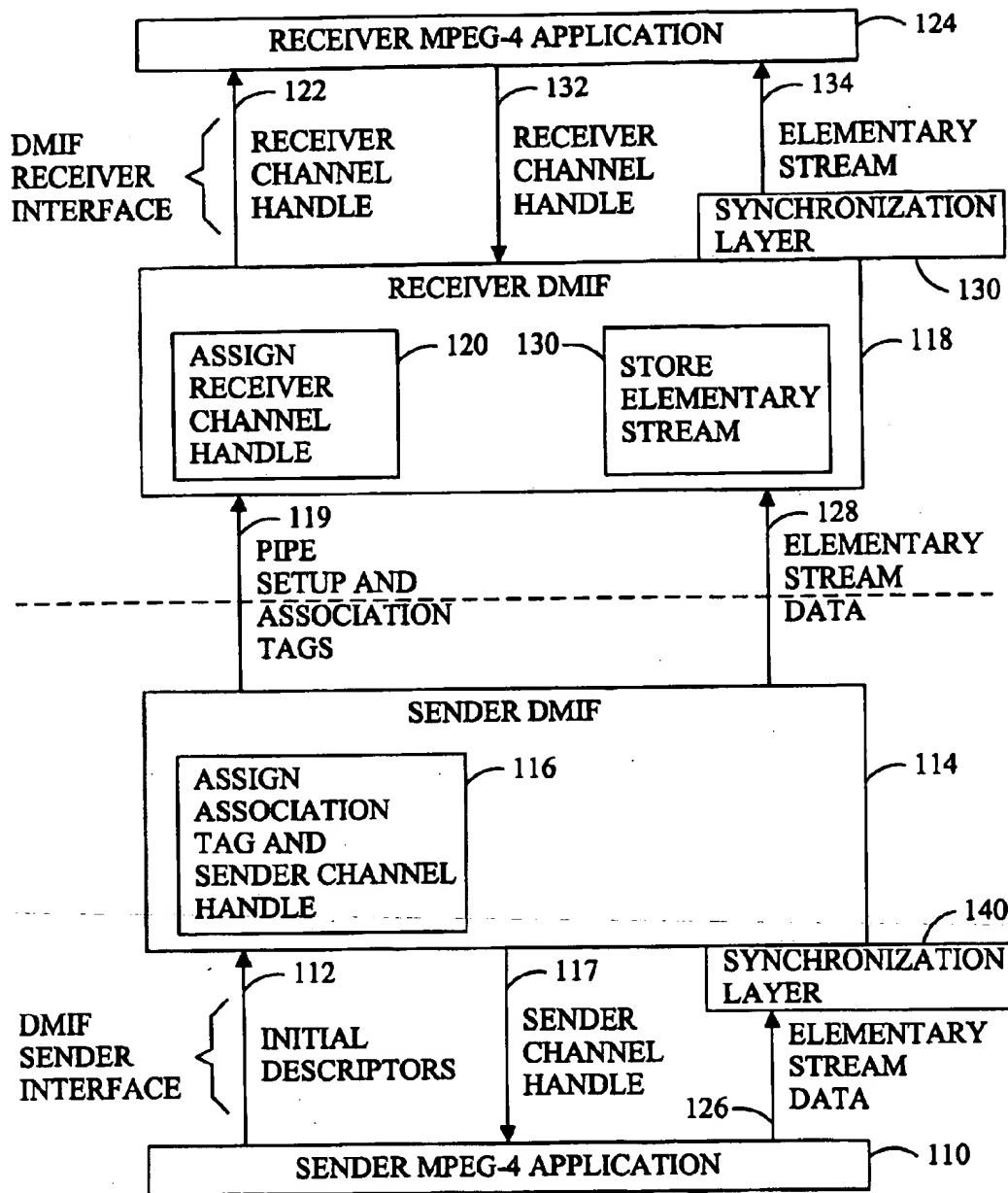36 — AL-PDU CONFIGURATION DESCRIPTION

FIG. 4

FIG. 5

AUDIO/VIDEO SYSTEM WITH AUXILIARY DATA

The present application is a continuation of co-pending patent application, Sezen et al., Ser. No. 60/049,078, filed Jun. 9, 1997.

BACKGROUND OF THE INVENTION

The present invention relates to a system for encoding, sending, and receiving audio and video that includes auxiliary data.

Digitally encoding video, consisting of multiple sequential frames of images, is a common task that traditionally has been performed by dividing each frame into a set of pixels and defining a sample luminance value, and possibly a color sample value, for each pixel. The development of powerful inexpensive computer technology has made it cost effective to develop complex systems for encoding moving pictures to achieve significant data compression. This permits, for example, high definition television (HDTV) to be broadcast within a limited bandwidth. The international standard which has been chosen for the transmission of HDTV is the Moving Pictures Experts Group 2 (MPEG-2) standard. The MPEG-2 video compression standard is based on both intra and inter coding of video fields or frames and achieves compression by taking advantage of either spatial or temporal redundancy in the video sequence.

An additional video encoding system has been proposed, designated as the MPEG-4 standard. MPEG-4 is a system of encoding video by which a moving picture composed of a sequence of sequential frames, generally accompanied by audio information, may be transmitted or otherwise sent from a moving picture sending device ("sender") to a moving picture receiving device ("receiver") in an efficient and flexible manner. Interactive applications are also anticipated in the MPEG-4 standard, but for ease of description, this patent application describes the case in which a moving picture is sent from the sender to the receiver only. It is to be understood that this patent application includes the case in which control information may be sent from receiver to sender.

MPEG-4 supports the transmission of a "Binary Format for Scene Description" (BIFS) which specifies the composition of objects in a sequence of frames or fields representing a three dimensional scene. In BIFS a scene is divided into a plurality of "scene elements." For example, as shown in FIG. 1A, a scene with a presenter, a blackboard, a desk, a globe, and an audio accompaniment is broken up into scene elements in panel 12, and reconstituted into a complete scene, with all the scene elements properly arranged in panel 14. In other words, each frame of a MPEG-4 based video system is composed of a plurality of scene elements that are arranged according to directives specified in the associated BIFS information. As such MPEG-4, similar to MPEG-2, is directed to a system for encoding and transmitting video and audio information for viewing a movie, albeit using a different protocol than MPEG-2. An example of a suitable systems decoder for MPEG-4 is shown in FIG. 1B.

Referring to FIG. 2, each scene element 20 is represented by an object to which is assigned a node 26 in a generally hierarchical tree structure (panel 16). The scene elements requiring input streaming data include an object descriptor 14. The tree structure provides a convenient data structure for representing a sequence of video fields or frames. Each object descriptor in turn includes at least one elementary stream descriptor 28 which includes such information as the

data rate, location information regarding the associated data stream(s) and decoding requirements for its respective logical channel (described below) for updating information regarding the data object. The data stream sent through a particular pipe for a particular object descriptor is generally referred to as an elementary stream. Such information may include, for example, data describing a change in shape, colorization, brightness, and location. Every elementary stream descriptor includes a decoder type (or equivalent stream type structure) which publishes the format or encoding algorithm used to represent the transmitted elementary stream data. FIGS. 3 and 4 show a simplified object descriptor format and an elementary stream descriptor format, respectively.

In an MPEG-4 system, both the sender and the receiver can use a respective "Delivery Multimedia Integration Framework" (DMIF) for assigning the data channels and time multiplexing scheme based on requests from the MPEG-4 applications. The DMIF, in effect, acts as an interface between an MPEG-4 application and the underlying transport layer, sometimes referred to herein as a "data pipe." The pipes generally refer to the physical or logical interconnection between a server and a client. As an object descriptor is sent from the sender to the receiver, the sender DMIF examines each of its elementary stream descriptors 28 and assigns a pipe to each one based on the requirements 30, 32, 34 and 36 included in the elementary stream descriptors 28. For example, an elementary stream with a more exacting quality of stream requirement 34 would be assigned a pipe that would permit high quality transmission. The pipe assignment is sent to the receiving DMIF. For example, depending on the transmission system each pipe (logical channel) could be a different periodic time portion of a single connection; each pipe could be different connection through the internet; or each pipe could a be different telephone line. In general, DMIF establishes the connections and ensures that both the sender and the receiver are in synchronization for tying a particular pipe to a particular elementary stream at both the sending and the receiving end.

The DMIF also assigns an association tag to each elementary stream. This tag provides a single identification of each elementary stream from the sending DMIF to the receiving DMIF and vice versa. Accordingly, the association tag is a unique end-to-end DMIF pipe identifier. Any channel change or reassignment initiated by the sender or receiver (for an interactive system) would require a different association tag.

Referring to FIG. 1B, DMIF delivers data to an MPEG-4 application by way of "Access Unit Layer Protocol Data Units" (AL-PDUs). The AL-PDUs configuration descriptor 26 in the elementary stream descriptor 28 (FIG. 4) specifies the AL-PDUs time coordination and required buffer size characteristics. The purpose is to ensure that AL-PDUs will arrive in a timely manner and conveying enough data to permit the data object to be fully updated for timely display. The AL-PDUs are stored in decode buffers, are reassembled into access units, are decoded (in accordance with the Decoder Type associated with the elementary stream), and stored in a configuration buffer, to be placed into the scene by the compositor which arranges the scene elements of the scene. DMIF also configures the multiplexing and access layer for each elementary stream based on its AL-PDU Configuration Descriptor. When DMIF is not used (typically in the case of a storage network), the association tag is substituted for a channel number identifying a logical or a physical channel containing the elementary stream.

The process of sending a video stream begins with a moving picture request from the receiver application (in a

broadcast system the request goes no further than the receiver DMIF), followed by a sequence of data from a sender application designed to establish an initial scene configuration. In FIG. 4, one of the decoder types is for scene description and another is for object descriptors. In the initial scene configuration a number of object descriptors are typically established. Each data object descriptor includes at least one elementary stream descriptor.

Another issue faced in an MPEG-4 system is avoiding collision among elementary stream identifiers when two applications run simultaneously on top of the same DMIF session. Each elementary stream ID is unique within an application. Therefore, the underlying DMIF session must be able to distinguish requests from each application in the case where elementary stream ID values collide.

Hamaguchi U.S. Pat. No. 5,276,805 discloses an image filing system in which retrieval data for a first set of images is associated with image data for a first image that is logically associated with the first set of images. For example, a user viewing an x-ray image of a patient's kidney would be able to view a list of a set of x-ray images taken from the same patient and be able to quickly view any of the set of x-ray images upon request. Hamaguchi teaches that the retrieval information is associated with the image as a whole.

Judson U.S. Pat. No. 5,572,643 discusses an already existing technology, known as hypertext, by which an internet browser permits a user to access an internet URL by clicking on a highlighted word in a page accessed on the internet. Judson teaches that the retrieval information is associated only with the test. Cohen et al. U.S. Pat. No. 5,367,621 is quite similar to Judson, permitting a user to click on a word in an on-line book, thereby causing a multimedia object to be displayed. Both Judson and Cohen et al. disclose advances linking together data which is unrelated to the encoding and data compression necessary for MPEG-2 and MPEG-4.

SUMMARY OF THE INVENTION

In a first embodiment, the present invention is a video system that includes a plurality of frames of video each of which is defined by a plurality of scene elements. The scene elements for a respective frame together define an image of the frame. First auxiliary data is descriptive of a first scene element of the frame and second auxiliary data is descriptive of a second scene element of the frame. A sending device sends the frame of video, including its scene elements, the first auxiliary data, and the second auxiliary data, from the sending device to a receiving device.

Auxiliary data is data which does not directly represent audio or video but is at least one level of abstraction away from a direct audio or video representation or is information which is in some way related to the object. By including auxiliary data with the video system descriptive of the individual scene elements, in contrast to the entire frame, additional information specific to scene elements becomes available to the receiver. As an example, the additional information may be displayed on command or used to further process the video information. This information may or may not be synchronized to the data stream(s) conveying the scene element sequence.

In another embodiment of the present invention the video system includes a plurality of frames of video, each of which defines an image. Each of the frames is defined by a plurality of pixels. First auxiliary data is descriptive of a first portion of the pixels of the frame and associated with a first portion

of the pixels. Second auxiliary data is descriptive of a second portion of the pixels of the frame and associated with a second portion of the pixels. A sending device sends the first portion of the pixels, the first auxiliary data, the second auxiliary data, and the second portion of the pixels to a receiving device.

The inclusion of auxiliary data into video systems that define each frame by a group of pixels, such as MPEG-2, allows sub-portions of each frame to be associated with the auxiliary data for subsequent use.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1A is an illustration of the data encoding and scene reconstruction of MPEG-4.

FIG. 1B is an illustration of a systems decoder for MPEG 4.

FIG. 2 is an illustration of the data structure of MPEG-4.

FIG. 3 is an illustration of an MPEG-4 object descriptor.

FIG. 4 is an illustration of an MPEG-4 elementary stream descriptor.

FIG. 5 is an illustration of a receiver DMIF and a sender DMIF user interfaces according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

When MPEG-4 was first conceived, it was anticipated that it would be a system for compressing and then subsequently decompressing and displaying visual and audio data. This is in accordance with previous video compressing systems, such as MPEG-2. The present inventor came to the realization that other types of data that are specific to scene elements would be useful to the user and greatly expand the potential of an MPEG-4 system. For example, information concerning a visual object, such as the height of a building, the make or model of an automobile, a basketball player's statistics, or a link (pointer) to related information may be of interest to a viewer. Also, statistical information about the visual object, for instance a color description describing and quantifying the coloration of a particular object may be of use to the receiver in correctly displaying the object. In addition, data describing audio elements may also be included. This type of data is, in this application, referred to as "auxiliary data." Auxiliary data is data which does not directly represent audio or video but is at least one level of abstraction away from a direct audio or video representation or is information which is in some way related to the object. Auxiliary data can be used to enhance the original video/audio service experienced by the viewers.

In a preferred embodiment of the present invention, auxiliary data may be displayed, on command, in association with a scene element. For example, a person watching a basketball game may wish to learn more about any one of the players. Television sets, or other display systems, may be equipped with a mouse, a remote command unit, or other pointing device to select scene elements being displayed. Using such a device, a viewer could point to one of the basketball players, press a button, and thereby cause the players statistics to be displayed. Such auxiliary data may be transmitted in a simple ASCII format. The user may select

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where the information is displayed, for example at either the top or bottom of the screen. Another use for auxiliary data is for an on-screen program guide with brief program descriptions. The brief program descriptions of the program guide provided may be selected to obtain a more complete description of the programming. Yet another use of auxiliary data is to obtain additional information about an actor while viewing a television show.

Other uses for the auxiliary data could be in conjunction with "hot buttons" displayed on the television screen. For example, there could be a hot button for a prewritten commentary on the show, or to allow the viewer to see and to add to a running commentary by viewers watching the show.

The preferred embodiment of the present invention includes an elementary stream descriptor, similar to that shown in FIG. 2 but in which one or more decoder type (or equivalently, stream type) structures announce the presence of one or several auxiliary data streams encoded according to the format specified by decoder type. The elementary stream descriptor(s) including such decoder type (or stream type) structure may be included in an object descriptor featuring elementary stream descriptor featuring other values of decoder type (or stream type) like MPEG-4 visual streams. In this case the auxiliary data is associated with and complements the elementary streams published by these elementary stream descriptor(s). In another situation, the elementary stream descriptors announcing the presence of auxiliary data may be included in an object descriptor which does not feature elementary stream descriptors featuring other kinds of decoder type (or stream type). In this situation, the auxiliary data may be associated and may complement a scene element 20 in a node 26 which is directly linked to the node publishing the auxiliary data object descriptor.

The present invention ensures that the elementary streams and the associated auxiliary data streams can be unambiguously identified in the MPEG-4 player as a result of the DMIF assigning an association tag to each elementary stream. The association tag data is transmitted via a control message from the sender DMIF and to the receiver DMIF. A separate channel handle uniquely representative of the use of an association tag by an application is assigned at run-time by the server and the client DMIF, respectively. Not only does this provide the receiving application with a shorthand way of referencing the channel conveying the AL-PDUs, but it avoids confusion when at least two applications using the same elementary stream identifier are running simultaneously in the same DMIF session.

FIG. 5 illustrates the assignment of association tags and channel handles. The sender MPEG-4 application 110 sends the initial object descriptors, including elementary stream descriptors (transmission 112) to the sender DMIF. The sender DMIF 114 during setup assigns an association tag and a sender MPEG application program channel handle to each requested elementary stream (step 116) and passes the sender channel handle back to the sender MPEG-4 application (step 117). The receiver DMIF 118 assigns a receiver channel handle to each requested elementary stream (step 120) and passes it (step 122) to the receiver MPEG-4 application 124, thus creating an end-to-end pipe indicator composed of the sender channel handle, association tag, and receiver-channel handle. When elementary stream data is sent from the sender MPEG-4 application 110 to the sender DMIF 114, it is first processed by the MPEG-4 synchronization layer 140. The packetized, possibly time stamped, possibly multiplexed elementary stream is then transmitted

to the receiver DMIF (step 128) and then processed by the receiver MPEG-4 synchronization layer 130 which reassembles the elementary stream as well as ensures timely presentation of the data to the application.

In an alternative embodiment of the present invention, MPEG-2 is equipped with a similar feature. The auxiliary data is inserted and multiplexed at the sending device into an MPEG-2 transport stream. In one preferred embodiment, the auxiliary at the sending device into an MPEG-2 program. This is accomplished by assigning a special stream type value specifying that the type of program element carried within the packets is auxiliary data encoded according to a particular format. Values of stream-type have already been defined in Table 2-29 of the MPEG-2 systems specification (IEC/ISO 13818-1) which permit the announcement of various video, audio and command/control protocol streams. The stream type value assigned to the auxiliary data stream is then transmitted to the receiver by means of the TS program map sections structure defined in Table 2-28. The auxiliary data stream(s) stream type and elementary PID value(s) are added to the relevant program (defined by program number in the TS program map sections structure). The inner descriptor loop in the TS program map section may be used in connection with the auxiliary data stream type to provide additional, high level, information about the auxiliary data service. The TS program map sections allows the transmission and reconstruction in the receiver of the program map table. The program map table provides the mapping between program numbers and the program elements comprising them. The elementary PID value associated with the auxiliary data stream type specifies the packets conveying the auxiliary data in the MPEG-2 transport stream. The auxiliary data is associated and enhances the service provided by other streams (video or audio elementary streams, for example) published in the program map table. Each program may feature one or several auxiliary data streams. In another embodiment, the auxiliary data streams are announced and associated with other streams like video or audio elementary streams in an MPEG-2 program stream map structure (defined in Table 2-35 of ISO/IEC 13818-1). This is achieved by assigning a particular (stream type, elementary stream ID) tuple to announce a particular auxiliary data stream format. Values of elementary stream ID have already been defined in Table 2-18 of ISO/IEC 13818-1 which can be used to publish the presence of video or audio streams in the multiplexed stream. The inner descriptor loop associated with the auxiliary data stream type may be used to convey additional, high-level information about the auxiliary data service. In either embodiments, and if the program includes reference to at least one video elementary stream, a given auxiliary data stream may be associated with only a portion of the transmitted video portion. Such portion may correspond to a specific region on the television display screen. In other words, the auxiliary data is associated with a particular block of picture elements (pixels) of a scene. Because of encoding mechanism used by MPEG-2 video specification (ISO/IEC 13818-2), it is preferable to define such picture block to coincide with boundaries of a set of contiguous 16×16 pixel blocks. Furthermore, if the data object to which the auxiliary data was associated at the sending device was moving about the screen, the auxiliary data may be reassigned to pixel sets on substantially a frame-to-frame or field-to-field basis.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

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What is claimed is:

1. A video system comprising:

(a) a plurality of frames of video each of which is defined by a plurality of scene elements, where said plurality of scene elements for a respective frame together define an image of said respective frame, wherein each of said scene elements is a separately encoded image with respect to other scene elements for said respective frame, wherein said image is created by composing said separately encoded scene elements within a respective frame based upon location information defining the position of said scene elements within said respective frame by a receiving device of said video system;

(b) first auxiliary data descriptive of the content of a first scene element of said plurality of scene elements for said respective frame;

(c) second auxiliary data descriptive of the content of a second scene element of said plurality of scene elements for said respective frame; and

(d) a sending device that sends a bitstream representing said respective frame of said video, including respective said separately encoded scene elements and said location information, said first auxiliary data, and said second auxiliary data, from said sending device to said receiving device, wherein said separately encoded scene elements are sent from said sending device to said receiving device using at least two elementary streams.

2. The video system of claim 1 wherein said video includes audio information.

3. The video system of claim 1 wherein said scene elements are overlapping.

4. The video system of claim 1 wherein said first auxiliary data is a set of descriptors and parameter values resulting from said first scene element.

5. The video system of claim 1 wherein said first auxiliary data is not directly representative of an image.

6. The video system of claim 1 wherein said first auxiliary data is viewable on a display device by selecting said first scene element.

7. A video system comprising:

(a) a plurality of frames of video each of which defines an image of said respective frame, each of said frames defined by a plurality of pixels;

(b) first auxiliary data descriptive of the content of a first portion of said pixels of a respective frame and associated with said first portion of said pixels of a respective frame and associated with said first portion of said pixels;

(c) second auxiliary data descriptive of the content of a second portion of said pixels of said respective frame and associated with said second portion of said pixels, where said first portion is different than said second portion; and

(d) a sending device that sends said first portion of said pixels, said first auxiliary data, said second auxiliary data, and said second portion of said pixels to a receiving device.

8. The video system of claim 7 wherein said video includes audio information.

9. The video system of claim 7 wherein said first portion and said second portion are blocks of 16 by 16 pixels of said respective frame.

10. The video system of claim 7 wherein said first auxiliary data is a set of descriptors and parameter values resulting form said first portion.

11. The video system of claim 7 wherein said first auxiliary data is not directly representative of an image.

12. The video system of claim 7 wherein said first auxiliary data is viewable on a display device by selecting said first portion.

13. A video system comprising:

(a) a plurality of frames of video each of which is defined by a plurality of scene elements, where said plurality of scene elements for a respective frame together define an image of said respective frame, wherein each of said scene elements is a separately encoded image with respect to other scene elements for said respective frame, wherein said image is created by composing said separately encoded scene elements within a respective frame based upon location information defining the position of said scene elements within said respective frame by said video system;

(b) each of said scene elements defined by a scene description format including a scene element data object format that defines the number of elementary streams and elementary stream descriptors;

(c) each of said elementary stream descriptors including a decoder type identifier;

(d) each of said decoder type identifiers represents at least one of an audio stream, a video stream, object descriptor, and auxiliary data, with at least one of said decoder type identifiers represents said auxiliary data; and

(e) said auxiliary data descriptive of the content of a respective one of said scene elements.

14. A system for encoding a moving picture comprised of a sequence of time separated frames depicting scenes, wherein each of said frames is defined by a plurality of scene elements, wherein each of the scene elements is a separately encoded image with respect to other scene elements for the respective frame, wherein said image is created by decoding a bitstream and composing said separately encoded scene elements within a respective frame based upon location information defining the position of said scene elements within said respective frame, said system comprising a scene description format, referencing at least one of said scene elements, including a scene element data object format that includes an elementary stream descriptor format including, in turn, a decoder type identifier format wherein any one of a set of decoder types may be represented by one out of a set of predetermined bit values and one of said predetermined bit values represents an auxiliary information decoder type, wherein said auxiliary information is descriptive of the content of at least one of said scene elements.

15. The system of claim 14 wherein an audio stream is also encoded.

16. A system for encoding a moving picture comprised of a sequence of time separated frames, wherein each of said frames includes a plurality of scene elements that are a separately encoded image with respect to other scene elements for a respective frame, said system adapted to divide said frames into scene elements, wherein said frame is created by composing said scene elements within said respective frame based upon location information defining the position of said scene elements within said respective frame by said system, and including a receiver display subsystem adapted to receive and display said frames and a pipe assignment subsystem adapted assign pipes to the scene elements and wherein said subsystem assigns at least one of a logical and physical transmission channel designator to each pipe and transmits a quantity representative of said pipe

designator to said receiver display subsystem, wherein said system includes a plurality of auxiliary data descriptive of the content of a respective plurality of scene elements.

17. The system of claim 16 wherein an audio stream is also encoded.

18. The system of claim 13 wherein said plurality of frames including said scene elements are represented in a bitstream.

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